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Assessing the impact of renewable energy deployment on local sustainability: Towards a theoretical framework

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Abstract

Renewable energy sources (RES) have a large potential to contribute to the sustainable development (SD) of specific territories by providing them with a wide variety of socioeconomic and environmental benefits. However, the existing literature has put much emphasis on the environmental benefits (including the reduction of global and local pollutants), while socioeconomic impacts have not received a comparable attention. These include diversification of energy supply, enhanced regional and rural development opportunities, creation of a domestic industry and employment opportunities. With the exception of the diversification and security of energy supply, these benefits have usually been mentioned, but their analysis has been too general (i.e., mostly at the national level) and a focus on the regional and, even more so, the local level, has been lacking. At most, studies provide scattered evidence of some of those regional and local benefits, but without an integrated conceptual framework to analyse them. This paper tries to make a contribution in this regard by developing an integrated theoretical framework which allows a comprehensive analysis of the impact of renewable energy on local sustainability and which can be empirically applied to identify these benefits in different territories.

Keywords: Renewable energy; Regional development; Local sustainability

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1. Introduction: aims, scope and methodology

It is usually stated that renewable energy sources (RES) contribute to the sustainability of specific territories by providing them with a wide variety of socioeconomic and environmental benefits. The later have been the focus of numerous studies on the reduction of emissions of local and global pollutants to the atmosphere. Since RES lead to lower emissions of several pollutants than fossil-fuel energy sources, the existing literature has stressed the global environmental benefits of renewable energy in terms of avoided CO_2 emissions. Climate change mitigation is a major policy goal for most OECD countries, which regard renewable energy deployment as one of the alternatives to help them comply with their Kyoto Protocol targets.

In contrast, although the socioeconomic benefits of RES are also mentioned, they have generally not received a comparable attention. These benefits include diversification and security of energy supply, enhanced regional and rural development opportunities,

creation of a domestic industry with export potential and employment opportunities.[1] These benefits have already proven important in those countries with high renewable energy deployment levels. But, surprisingly, there have been very few empirical studies focusing on the real impact of RES on those socioeconomic variables.

This is even more paradoxical given that, in some developed countries, the implementation of RES promotion policies was politically justified for those socio-economic benefits.[2] After a period where the main focus was laid on the environmental benefits, the socioeconomic benefits are gaining increasing attention. This is stressed by a recent communication from the European Commission stating that ''a substantial part of the public benefits pursued by policies supporting renewables relate to employment and social policies, and rural development while other national policy goals should be respected and duly take into account'' [8].

Some of the socioeconomic characteristics of many territories make them particularly suitable to benefit from renewable energy investments, such as relatively large share of rural, dispersed population, high dependence on a declining agricultural sector (in a context of reduced agricultural subsidies), high unemployment rates, scarcity of regional development alternatives, declining populations and aging of the remaining population. Surprisingly, there have been very few empirical studies focusing on the real impact of RES on those socioeconomic variables and even more so at the local, rural and regional levels.

Several studies provide evidence of some of those benefits, but they lack an integrated conceptual framework to analyse them. This paper makes a contribution in this regard by developing an integrated theoretical framework which allows a comprehensive analysis of the socioeconomic impact of RES on local (rural and regional) sustainability and which can be empirically applied to identify this impact in different territories.

Accordingly, the paper is structured as follows. The next section provides an interpretation of the concept of regional sustainable development (SD). Section 3 includes an overview of the literature on the local socioeconomic benefits of renewable energy deployment. A theoretical framework to empirically analyse the contribution of renewable energy to sustainability is developed in Section 4. The paper closes with some concluding remarks and policy implications.

2. The concept of regional SD

SD has traditionally been defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs [3]. However, this is far from being an operative definition which could allow us to say whether a given country or region is in a transition process towards sustainability or the extent to which a given development proposal is ''sustainable''.

Particularly, the territorial dimension of SD calls for the use of a more operative approach to sustainability which is adapted to the regional or local territorial contexts. In this regard, two major conceptual frameworks to assess the sustainability of specific

[1] The diversification and security of energy supply provided by RES has received a significant attention in Europe, given the fact that most European countries are energy importers (from areas with relatively high geopolitical risks) and that RES are an indigenous source of energy (see [1]). This attention has increased in the last years (see [2]).

[2] This is, for example, the case in Spain, where promotion of renewable energy was initially justified as a way to create jobs in a country with a high unemployment rate.

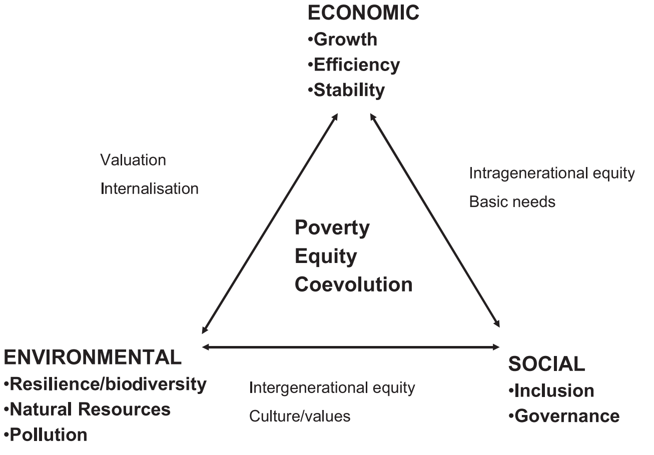


Fig. 1. The dimensions of sustainability and their interrelationships (*Source*: [4]).

development projects in specific territorial areas can be distinguished: substantive and procedural sustainability.

The first one considers how a specific project contributes to the improvement of the economic, social and environmental conditions of a specific territory and, thus, to the welfare of its population. The literature on SD has tried to make this substantive approach operative through three major approaches: (1) sustainability as the maintenance of the stock of capital (natural, man-made, human and socio-cultural); (2) the triangular approach, which considers the three interrelated dimensions of sustainability (economic, social and environmental); and (3) the materials balance approach.[3] Regarding substantive sustainability, this paper adopts a combination of the first and second approaches and tries to provide an analytical framework to identify how a specific renewable energy project may influence the economic, social and environmental dimensions of the sustainability of a given territory.

The triangular and constant-capital approaches take into account the three dimensions of SD (economic, social and environmental) and try to assess the sustainability of a given development proposal according to them (Fig. 1).[4]

Therefore, following this approach, a sustainable regional (local) policy must tackle the three dimensions of sustainability with the aim to increase the standard of living of its citizens:

- *Environmental*. Reduction of local pollution, exploitation of the natural resources in the territory and maintenance of the resilience (ability to adapt to change), integrity and stability of the ecosystem.
- *Economic*. Increase of regional per capita income, improvement in the standard of living of the local population, reduction of energy dependence and increase in the diversification of energy supply.

[3]For an overview of these approaches, see, respectively, [4] (constant-capital approach), [5] (triangular approach) and [6] (materials balance approach).

[4]SD implies that the objectives of these three dimensions should be jointly maximised, taking into account the possible *trade-offs* between these subsystems.

- *Social*. Some authors stress that SD cannot be achieved without the sustainability of social and cultural systems, which includes the achievement of peace and social cohesion, stability, social participation, respect for cultural identity and institutional development. Reducing unemployment and improving the quality of jobs (more permanent jobs), increasing regional cohesion and reducing poverty levels are key actions at local level to achieve social sustainability. Activities such as renewable energy deployment, which are an alternative to traditional agriculture, should be encouraged. This has a particularly positive psychological impact on the prospects of the young local population.

This paper argues that the deployment of renewable energy projects may contribute to these three dimensions of local sustainability.

However, a given project should not only be sustainable according to the aforementioned three dimensions. It should also comply with the "procedural sustainability" approach. This is a participatory approach which takes into account the opinions and interests of all stakeholders [10]. This calls for a wide social participation process in the implementation of SD instruments and activities at the local level whereby all interested parties are involved.

The "procedural sustainability" stream of the literature argues that the analysis of the sustainability of a given development proposal (project) should not only focus on the impact of this proposal but, also, on how this impact is perceived by the local population, how the benefits are distributed among the different actors and how this perception and distribution affect the acceptance of the project and, thus, its feasibility.

Therefore, procedural sustainability is very relevant when considering a development project. A wide array of stakeholders and their mutual relationship should be considered when implementing a project and this actor network may either facilitate or discourage such implementation. The interests, strategies and behaviour of local agents with respect to the renewable energy project should be analysed. Thus, we will integrate this approach into our comprehensive theoretical framework.

Therefore, a local SD strategy should combine a top-down (triangular sustainability) and a bottom-up (procedural sustainability) approach. We argue that both approaches are crucial to analyse the contribution of RES to local and regional sustainability. First, renewable energy deployment can contribute to the three sustainability dimensions at the regional level. Second, the existence of local participatory processes is crucial for the implementation of renewable energy projects because the acceptance of this project by the socioeconomic actors in a given territory facilitates its deployment.

3. The contribution of renewable energy to local sustainability: a brief overview of the literature

The literature on RES usually mentions their socioeconomic and environmental advantages. However, the analysis of the socioeconomic benefits has been rather general.

In fact, the environmental have been the only benefits analysed in depth.[5] Several studies have analysed the environmental benefits in terms of reduction of the emissions of global and local pollutants resulting from the substitution of conventional energy for RES (see,

[5]The possible exceptions to such statement are employment benefits, where there has been a significant amount of literature.

among others, [7–9]) and many authors emphasise the contribution of RES to the environmental dimension of sustainability (see, e.g., [11]).

In contrast, the socioeconomic benefits of RES have only been generally dealt with except, perhaps, the employment benefits and the reduction on the imports of fossil-fuel energy sources it brings. There is a dramatic scarcity of empirical analysis on the contribution of RES to the development of specific regions and, particularly, to rural areas with high unemployment levels and a declining population. The creation of a few jobs may have a significant impact on isolated local communities with scarce development and employment alternatives.

To build a solid conceptual base on the topic, we have reviewed the relevant literature. We can distinguish those studies which analyse the contribution of renewables to the sustainability of development in an abstract, generic manner and those which have focused on the impact of the deployment of renewables on employment.

3.1. The literature on the contribution of renewable energy deployment to socioeconomic sustainability

With respect to the former type of studies, and given the narrow link between poverty and lack of access to energy sources, the existing literature has focused on the possible contribution of renewables to the SD of less developed and developing countries (see, among others [11–17]).

These studies focus on the relationship between access to energy, poverty alleviation and environmental protection. They emphasise the contribution of RES to poverty reduction and to the improvement in the standard of living of the population. Particularly, they stress that RES offer an interesting decentralised energy option which allows access to energy and electricity supply for isolated and distant areas which cannot be reached by the electricity grid at a reasonable cost. An additional motivation to support the deployment of RES for many countries is the benefits in terms of rural development.

Some of these studies provide some evidence on the contribution of RES to the sustainability of rural areas. For instance, Reddy et al. [18] analyse the impact of small hydro on the local sustainability of regions in the North of India and identify the impact of RES on the different components of local capital which make up their sustainability framework: financial, natural, social, physical and human. The authors show that the success of renewable energy systems depends on the resource endowments, the socioeconomic conditions and the cultural features of local communities. They analyse the perception and participation of local communities in the successful implementation of these systems, concluding that the involvement of the local community in the RES project, as well as the existence of socioeconomic benefits for those local communities are necessary elements for the long-term sustainability of small hydro systems.

Among the socioeconomic benefits resulting from the deployment of RES, they find the reduction of migratory flows from rural to urban areas, the creation of local employment opportunities (by improving access to electricity) and local capacity building. However, there are positive but modest impacts on local income.[6]

[6]The study used a qualitative methodology which involved the consultation of local stakeholders, including local authorities, local beneficiaries and people negatively affected by the project, project developers (investors and generators) and NGOs and site visits.

El Bassam and Maegaard [19] suggest that RES could be the productive core of rural communities whereby farmers would be food and primary energy producers. These authors claim that the promotion of the use of biomass for electricity generation would provide a substantial impetus for the agricultural sector.

Within these "general" studies, most focus on developing countries, while only a few analyse the impacts of RES in developed countries, which is the focus of this paper.[7]

For example, Komor and Bazilian [20] analyse the motives for an ambitious RES policy in Ireland. Regarding the contribution of renewable energy to socioeconomic objectives, the study shows that the implementation of RES installations favours the productive diversification in less-developed regions, enhancing their competitiveness level and contributing to the reduction of regional income disparities. RES may improve both the quantity and quality of employment. However, not all RES can improve the temporariness of employment. For example, most of the employment created by wind energy is temporary and far from the local areas, taking place in the stage of equipment and component manufacturing. In contrast, biomass leads to more permanent jobs.

An interesting study analysing how local populations perceive the benefits of renewable energy is Bergmann et al. [21], who interviewed 219 households in Scotland on their valuation of the attributes of RES projects. The study shows that the socioeconomic attributes (and, particularly, employment creation) are less valued than the environmental attributes. However, employment creation is highly valued in rural areas.

An interesting quantitative study is ADAS [22], which develops an economic model based on the use of a Keynesian multiplier to measure the impact of local expenditures and the economic injection that the investment in RES involves.

The impact on rural development of achieving the UK target for renewable electricity in 2010 is analysed. The economic impact is estimated to be around 743 million £ and 2465 full-time jobs. Notwithstanding, most of the equipment and expertise is imported. Furthermore, there are limited possibilities for the provision of local O&M services, which are usually provided by non-local specialised equipment suppliers and this task requires few human resources. The potential contribution to rural development depends on the type of renewable energy technology considered.

A number of papers have analysed in a non-detailed, generic manner the contribution of renewables to socioeconomic development and to the reduction of environmental problems in several regions of Spain, one of the leading countries in the world regarding RES deployment. The following are worth mentioning in this regard: López et al. [23,24], Míguez et al. [25] and Faulin et al. [26]. These studies conclude that RES may significantly contribute to regional development and focus on positive employment effects. However, they provide very general data but the contribution of RES to local SD is not analysed in depth.

3.2. The literature on the impact of renewable energy deployment on employment creation

The literature on the employment impacts of renewable energy deployment generally observes a positive effect. This is supported by several studies, both in the European and

[7] Extrapolations of the results of developing country studies to developed countries are limited, however, given the different socioeconomic, political, institutional and cultural contexts of both types of countries.

the US contexts.[8] In general, the employment benefits of renewables occur in the agricultural and industrial sectors and can be classified in two groups:

- *Direct*. These include: (1) taxes on property, (2) revenues for land owners, (3) short-term benefits (linked to employment creation in local sales and construction) and (4) permanent benefits (O&M employment).
- *Indirect*. These might be greater than the direct effects, but are more difficult to calculate.

The studies generally show that RES is more labour intensive than conventional energy production for the same amount of energy produced.[9] However, other studies are more critical in this regard and also observe possible negative employment effects.

The impact on employment of an increase in RES depends to a large extent on the combination of renewable electricity technologies, on the employment intensity of the different stages of the renewable electricity chain and on the cost-efficiency in achieving the national renewable energy targets [31].

Some authors distinguish two types of impacts on employment [32]:

(1) An ''expansion effect'' on production and employment stemming from RES investments which would not be profitable without public support.
(2) A ''contraction effect'' due to the increase in electricity prices as a result of the greater costs of RES, which adds to investment reductions in the ''conventional energy'' sector. This higher cost, whose burden falls on the electricity consumer, leads to a reduction of production and employment in the electricity sector (reduced demand). A higher electricity cost for manufacturing firms also involves a reduction in their production and employment levels. The negative impacts on employment from the contraction effect may outweigh the positive impacts related to the expansion effect, leading to a net negative effect on employment. In the German case, Hillebrand et al. [32] observe that the expansion effect would dominate in the first years, resulting in 33,000 new jobs in 2004, 14,000 in 2006 and 2400 in 2008. However, the contraction effect would outweigh these employment gains and would lead to a negative impact on employment in 2010, with 6000 jobs being lost.[10]

Not all renewable energy technologies contribute in the same manner to these benefits. In the short-term, wind farms are likely to have the greatest impact. However, such impact may not only be short-term but also on places far from the project location. For example, the purchase of specialised equipment accounts for 75% of the capital cost of a wind farm. It is likely that its manufacturing takes place outside the local community.[11] In addition, a

[8]Concerning the European context, see [27,28]. Regarding the US context, see [29,30].

[9]These studies reach the same conclusions with different methodologies, which make these conclusions more reliable, although it is hard to compare the specific figures provided by each study.

[10]Other studies carried out in the German context lead to different conclusions. Whereas the net effect of RES on employment are positive for some studies, it is negative for others. Among the former we can mention a study by the German Environmental Agency [33]. Among the later, Pfaffenberg et al. [34] concludes that investment in RES will lead to an accumulated long-term net employment loss of 19000 jobs in a 20-year period.

[11]Local impacts would only include the production of local components, the final assembly, construction and O&M activities.

significant part of its economic impact occurs in the construction stage, which has a temporary economic impact. In contrast, biomass is likely to have more permanent economic impacts during the whole life cycle of the project. In this case, transport and processing of the biomass fuel account for the greatest share of total costs, which are spent in the local area or region.

It is highly relevant to consider both quantitative as well as qualitative employment impacts. The ability to provide a decentralised employment source is a great advantage of RES and it is related to the dispersion of RES across the territory. This leads to a more even and balanced employment creation, positively affecting geographical areas with scarce employment opportunities. This in sharp contrast with electricity from conventional energy sources, which are based on large fossil fuel combustion installations with a greater geographical concentration.

All in all, as stressed by the European Commission [9], jobs created in the RES business cannot be ''globalised'' to the same extent as others. Even if a country imported 100% of all the renewable energy technologies, a significant amount of jobs would still be created, linked to activities such as sales, installation and maintenance of renewable energy systems.

4. Building a theoretical framework to assess the impact of renewable energy deployment on local sustainability

The starting point of our theoretical framework is the distinction between procedural and substantive sustainability considered in Section 2. Both sustainability approaches should be considered when analysing the impacts of renewable energy deployment on local sustainability:

(1) *Impact on the three dimensions of sustainability*. Due account should be taken of the impacts of the project on the three sustainability dimensions (economic, social and environmental).
(2) *Perceptions of local stakeholders*. It is as important to consider the different local stakeholders and the economic, social and political relationships between them. The acceptance or rejection of the project by the local population can make the implementation of a renewable energy project and its contribution to local sustainability either a success or a failure.

Of course, both issues are interrelated. The local sustainability impacts of a renewable energy project depend on the features of the local actor network and on the conditions and characteristics of the stakeholders themselves. In turn, the greater the benefits for the local communities, the greater the attractiveness of rural areas and the greater the possibilities for the social acceptance and success of the project. At the end, support for renewables will depend to a large extent on the perception of its benefits at the territorial/local level.

Therefore, a wide array of stakeholders and their mutual relationships should be considered when implementing a project. The deployment of renewable energy projects would benefit from the previous engagement of local actors because the rejection of the project by these actors could make its implementation a difficult endeavour. Probably, the best method to analyse the interests, strategies and behaviour of local agents with respect to the renewable energy project is the approach of *stakeholder analysis* (see Section 4.2).

Furthermore, a direct link between the approaches of local sustainability (both substantive and procedural) and endogenous development should be made. Endogenous development can be conceptualised as a process which raises the income levels of the population based on the intrinsic resources of society and the respect for community values and traditions [35]. Crucial to the activation of the endogenous resources is the participatory approach to setting goals, procedures, and the implementation and control of economic activities. Thus, the local process of innovative entrepreneurship should meet the opportunities raised by enhancing traditional local sources of income and bringing in new activities and technologies.[12]

Endogenous development theory emphasises the advantageousness that the territories base their SD processes on the use of local resource endowments. Renewable energy investments provide an example of how those local resources (both physical and human) can be exploited in order to improve the prospects of the local population engaging them in an enduring rural development process. This issue has two main aspects:

(1) Local conditions and features making a territory particularly attractive for renewable energy investments.
(2) Impact of such investments on the standard of living of the local population.

This paper focuses on this later aspect.

Rural communities would benefit from the development of ''local productive systems'' in which the organisation, evolution and competitiveness of the local productive structure does not only depend on investment and technical progress but is integrated in the institutions, culture, habits and the social capital of the local area where the production process takes place.[13] We argue that renewable energy projects have the potential to achieve such integration between those elements (social, productive and territorial) placing local communities in a SD path.[14]

Fig. 2 synthesises the comprehensive analytical framework followed in this paper, which can be summarised as follows. The implementation of the renewable energy project would lead to a ''substantive'' local sustainability impact (three dimensions of local sustainability) and to a local development process based on the use of local resources. The extent to which this is so should be analysed, respectively, with insights from the substantive sustainability approaches (triangular and constant-capital) and the endogenous development theory. We assume that a local development process which is based to a large extent on local resources is more self-sustainable and enduring than another process based on resources which are mostly external to the local community/territory.[15] By their own character, renewable energy projects use those local resources to a large extent.

[12]For further details on the concept of endogenous development applied to rural regions, see [37,38]. Vázquez Barquero [39,40] has provided the analytical framework for the ''local development'' approach.

[13]Local development models based on industrial districts emphasise the relevance of this idea, see Ref. [41].

[14]However, the socioeconomic institutional and human resources in a territory can also be an obstacle for the implementation of the project. The sustainability impact of a given renewable energy project is mediated by the institutional context of the territory where it is applied and this context may not be favourable for such implementation. In this case, an attitudinal or an institutional change is necessary and local policy makers are crucial to encourage such change. Thus, a development process based on the use of local resources is a necessary (albeit not sufficient) condition for the sustainability of the territory.

[15]Of course, this does not mean that all resources should be locally based.

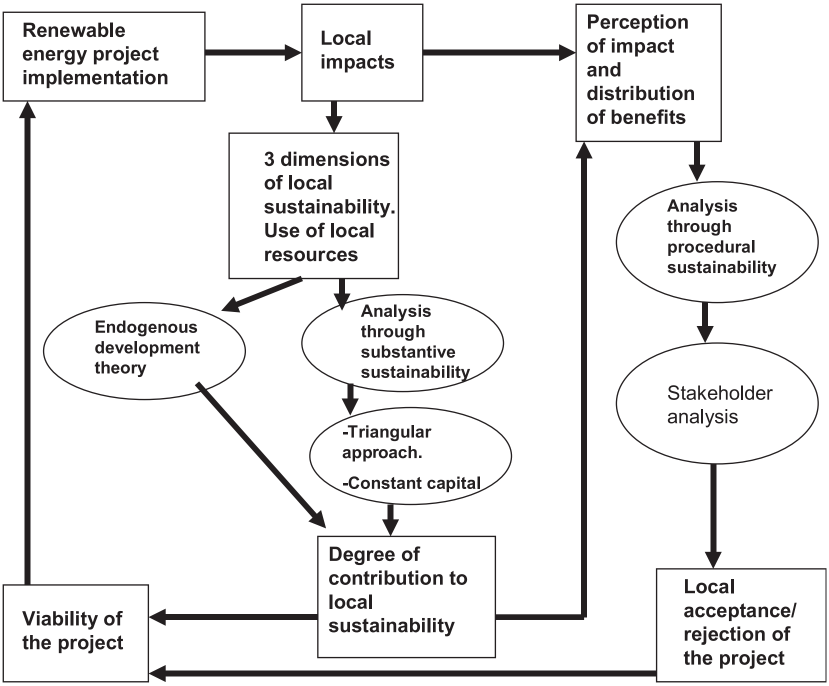


Fig. 2. Theoretical framework (*Source*: own elaboration).

This "substantive" contribution to sustainability can lead to social benefits whose distribution is uneven across different actors and/or are perceived differently by different stakeholders. This distributional and perception issues should be analysed as part of the procedural sustainability approach. The *stakeholder analysis* is particularly suitable in this context to analyse actors' interests, incentives and strategies as well as their mutual relationship and interactions. These interests and perceptions may lead to the acceptance of the project by the local population and, together with the "objective contribution" of the project to local sustainability, they are an essential ingredient in the viability of the project itself. The following two subsections will discuss these two issues (impacts and stakeholders interests) in the context of renewable energy projects.

4.1. The impacts

Renewable energy projects affect several dimensions of the socioeconomic sustainability of a given territory. The rest of this subsection provides an analysis of these potential impacts.[16]

4.1.1. Quantitative and qualitative impacts on employment

The literature shows that renewable energy projects may have significant impacts on employment. Nevertheless, some aspects of this issue deserve special mention.

[16] Given that this paper focuses on the socioeconomic variables, environmental impacts are not considered here in detail although, of course, they are very relevant in the assessment of the local sustainability of a renewable energy project.

Both quantitative and qualitative impacts should be taken into account: as important as the number of jobs created in a specific area is their continuity. This depends on, both, the stage of the renewable energy project and the type of renewable technology considered. For example, employment creation and income generation during the construction stage is significant, but generally temporary. In contrast, local employment creation in the O&M stage is more permanent but modest, particularly in the case of wind farms. Biomass is a special case in this regard because the renewable resource has to be supplied in order to be transformed into a primary energy source. The production, processing and transport of biomass are likely to have substantial employment effects.

Furthermore, in the context of rural SD, other qualitative aspects are highly relevant.

First, with the aim to increase social cohesion, a positive impact on the employment rates of specific sectors of the population is desirable and, particularly, on young people, women and long-duration unemployment.

It is worth analysing if the project has led to the hiring of those unemployed, if it has caused a transfer of workers from agriculture and farming to the renewable energy sector or if it provides a supplementary source of employment for the population, i.e., if local people maintain their agricultural activity in addition to working in the renewable energy project. The project can contribute to a desirable increase in the employment diversification, mitigating an excessive concentration on a declining agricultural activity.

It is also interesting to identify what type of employment is being created according to the level of skills (high/average/low). Given the likely low skills of rural workers, the greater the need to hire low-skill workers, the greater the positive impact of the project on the social cohesion of the local communities.

Finally, some of the jobs as a result of the project are not created in the local area.[17] The equipment is normally manufactured by firms located far from the project site.[18] Some of the employment generated in the O&M stage can be local, while some visits from specialised technicians from the firm's headquarters are required.

4.1.2. Income generation effects

The most relevant are payments to local farmers for hiring their land and "compensations" to the local community made by the owner of the renewable energy plant. As explained below, these compensation (either financial or in kind) facilitates the acceptance of the project by the local community, which is an element favouring its viability. Therefore, it should be identified:

(i) If there have been financial transfers from the firm to the local community, what has been the destination of such transfers? And, what has been the participation of the local population on such decision? Furthermore, the factors determining such income flows and their impact on the profitability of the project should also be analysed.
(ii) The benefit for land owners associated to hiring their land can be calculated taking into account the concept of "opportunity cost", and is the difference between the rents that

[17]There might also be indirect employment impacts induced by the project as a result of the increase in employment of people who live outside the local area, but spend money in goods and services produced by firms located in the area. This local impact is unlikely to be large and it is difficult to identify.

[18]In this context, an "influential area" for the project should be defined, encompassing the impacts caused within a radius of 50 km round the project's location (22).

are obtained by hiring the land compared to those from using the land for traditional agricultural crops.

4.1.3. Demographic impact

In a context of intense migration of the rural population, one of the main concerns is to stop such process by "fixing" population on the territory and, if possible, reverse the trends by encouraging immigration to the local area. Therefore, the impact of the project on migration and immigration should be analysed.

4.1.4. Energy impacts

Rural areas are not usually energy self-sufficient. The RES project uses endogenous energy resources and may mitigate such problem if a significant share of the energy consumption in the area is covered with the energy produced in the project. However, this may lead to a very limited impact because, at least in the case of electricity generation, power is fed into the general grid, which provides electricity to areas far from the project location. In some cases, the RES generation firm offers cheaper electricity to the local population as part of the aforementioned "compensations" in order to gain support for the project.

4.1.5. Educational impacts

Local workers in the project may receive specific training, which increases the education/training/skills levels of the population. Notwithstanding, a modest impact is likely to result, since the skills required are likely to be project specific. Providing funds for the construction of local libraries is another way to contribute to improve the educational levels of the local population but, again, the impact is likely to be modest.

4.1.6. Impact of the project on the productive diversification of the area

This is worth analysing. Given the uncertain prospects about the future of agriculture, renewable energy projects are particularly interesting when a large share of the regional value added is concentrated in the agricultural sector. However, renewable energy projects are certainly not a panacea which will solve the socioeconomic problems of rural areas, although they might contribute to improve the future prospects of their citizens.

4.1.7. Social cohesion and human development

Related to the above, the renewable energy project may improve these. As an alternative to traditional agricultural activities, the project may improve the socioeconomic prospects of the young population and, thus, the self-confidence of the general population, increase the level of engagement in associations (which is considered key for the social dimension of sustainability) and improve the quality and increase the quantity of social relations. Although these benefits are less tangible than others, they are key for local SD and to gain the support of local actors for the project.

4.1.8. Income distribution

Also related to the above, the reduction of income differentials has a positive impact on local sustainability. Therefore, it is desirable that the project leads to income and employment generation of less-favoured individuals. It should be analysed whether the benefits of the project fall on low-income groups and how the project contributes to poverty alleviation.

4.1.9. Impact on tourism

In theory, the project can have a "demonstration effect", attracting visitors and leading to an additional source of income from the local population. However, this impact is likely to be modest, mainly because a renewable energy project has a low attractiveness compared to competing tourist destinies.

4.1.10. Other impacts

The project is likely to lead to additional impacts in the following variables:

(a) *Local R&D&D*. As a high-technology sector, a renewable energy project may increase the level of local R&D&D. However, it is most likely that such activities are carried out in the laboratories of the firm, which are likely to be located far from the project's location. Therefore, the impact is likely to be modest.
(b) *Industry creation*. The manufacturing of renewable energy equipment is unlikely to take place in the project site and will probably be imported. Therefore, it is unlikely that a certain local area benefits from both the sitting of the project and the manufacturing of equipment.
(c) *Impact on the municipal budget*. A renewable energy project may have a positive effect on the municipal budget. First, there might be direct financial transfers from the firm, as part of the aforementioned "compensations". Second, the greater economic activity induced by the project leads to a greater local tax base, increasing the funds collected. Finally, the installation of the renewable energy project may entail the granting of subsidies to the firm and the local community from European funds or the national or regional governments.

4.1.11. Use of endogenous resources

An important issue in the context of sustainable endogenous development is the use made by the project of resources of all types (physical, human and capital) available in the territory. A bottom-up development process called "endogenous development" is based on the use of those local resources, in contrast to a top-down development process characterised by the settlement of firms originally from places beyond the rural area. Renewable energy projects are situated in intermediate position between both extremes. On the one hand, they take advantage of the physical resources in the territory. On the other hand, it has external elements, because both the technology and the know-how are usually from outside the area.

The use of local resources (and particularly its human capital) depends on the degree to which the project is embodied in the local productive structure, an issue that deserves an analysis. There are two extreme situations in this context:

(i) The project might be integrated within the local economy, leading to a backward (local suppliers) and forward productive linkage (final local customers). Such integration may not take place and the project might be "isolated" from the local economy leading to productive linkages, but not within the local territory.
(ii) The greater the integration of the project in the productive structure of the local economy, the greater its socioeconomic impact on the local community.

4.2. The actors

The implementation of the project can be facilitated if, as a result of the perception of its benefits, key local actors support it. Therefore, the perception of the socioeconomic benefits

by the local population should be analysed since the public acceptance of the project is directly related to such perception. This issue is related to procedural sustainability.

Several (local and non-local) actors will be affected by the implementation of renewable energy projects. Given the impact of these actors on the viability of the project, an analysis of their possible interests and strategies is worth undertaking. "Stakeholder analysis" is deemed the most suitable methodological tool for this task.

Stakeholder analysis is a process of systematically gathering and analysing qualitative information to determine whose interests should be taken into account when developing and/or implementing a policy or program. Stakeholders in a process are actors (persons or organisations) with a vested interest in the policy being promoted. Policymakers and managers can use a stakeholder analysis to identify the key actors and to assess their knowledge, interests, positions, alliances, and importance related to the policy. This allows policymakers and managers to interact more effectively with key stakeholders and to increase support for a given policy or program. When this analysis is conducted *before* a policy or program is implemented, policymakers and managers can detect and act to prevent potential misunderstandings about and/or opposition to the policy or program, increasing the probability that it will succeed [42].

Who are the key local stakeholders in the deployment of a RES project? How do the impacts of a RES project affect different local actors? Stakeholder analysis is the most suitable technique to identify the interests and strategies of actors regarding the new project. Answering these questions is crucial to identify how the impacts are distributed among the local population, who is likely to be more benefited and who may reject the project. The perceptions of potential winners and losers are an essential component in the analysis of the possible viability of the project. If a large share of the population rejects the project or a small but powerful minority does, the renewable energy installation will probably not be implemented.[19]

Fig. 3 identifies those actors who are more likely to be affected by renewable energy deployment. The arrows suggest that the renewable energy project has an impact on the stakeholders but that the interests and strategies of actors may also affect the viability of the project itself. The arrows between the actors refer to their interrelationships and interactions. Since this is rather an empirical question, the rest of this subsection provides a general discussion of their possible interests, incentives and strategies.

4.2.1. Renewable energy generators and investors

They benefit from the public support for RES but they also face investment risks. They can try to obtain facilities from the local government by convincing it that their project contributes to local sustainability (employment creation). But, on the other hand, they may have to provide certain compensations to the local community to get the social support for the project. This support might be a key element to ensure its viability, although it also reduces its profitability. These stakeholders can be regarded as an intermediary in the income transfer taking place between electricity consumers, who pay the costs of RES

[19]If implemented, the project will suffer the rejection of the people and it is unlikely to be successful and locally sustainable. This rejection may directly affect the profitability of the project. In fact, it is not uncommon that the project investors earmark some funds for the local community in order to increase social acceptance of an otherwise controversial project.

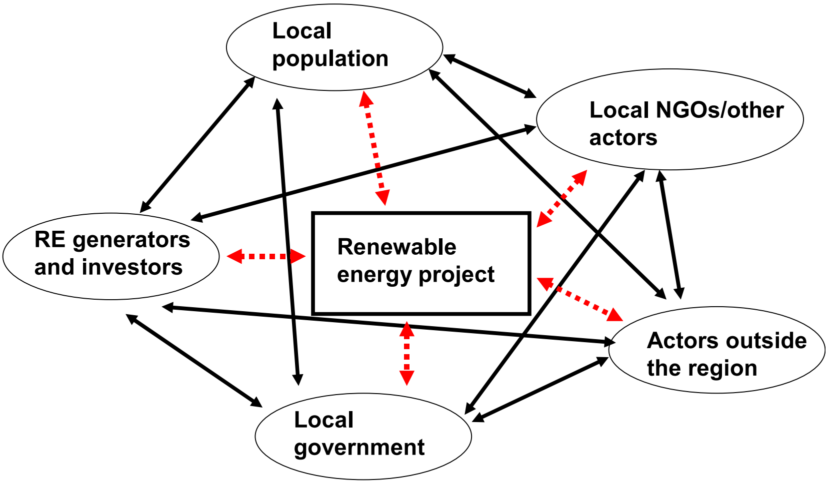


Fig. 3. Relevant stakeholders in renewable energy projects.

support, and the local community, who receive the financial support although they themselves keep part of such transfer.

4.2.2. *Local government (regional and/or municipal)*

They are interested in providing development alternatives to their population. Many rural areas are based on a declining agricultural activity with dark prospects, which leads to the migration of their inhabitants, specially the youngest ones. Therefore, renewable energy projects are generally welcome. The local government tends to provide certain facilities which make the area an attractive place for the location of the project. But, at the same time, it tries to increase the local benefits resulting from the project by asking for certain "compensations". These allow local policy makers to "sell" the project to their electoral constituency and can take many forms: a requirement to hire people from the local community, offer a lower electricity price, reduce the negative externalities from the project or build local infrastructures (such as roads, public libraries, swimming pools, …). However, the local governments have to be careful not to ask for too much "compensations" because, otherwise, the local area would lose their attractiveness for potential project developers. The results of the negotiation between both actors is an empirical issue which depends on the negotiation capabilities of each actor, their respective institutional context and the potential gains and losses for each of them.

4.2.3. *Local population*

Several actors might be affected by the project in different ways:

- *Directly and positively impacted farmers*. Farmers planting crops for biomass or who rent their land for sitting the project (i.e., wind farms or PV modules) are positively affected by the project, since it provides a supplementary source of income.[20] These farmers will

[20]As stressed by the European Environmental Agency [36], energy crops could be even more competitive than food crops.

have to compare the rents from their traditional agricultural activity with the income related to the renewable energy project activities. In the case of biomass, they would have to compare the revenues they earn from planting energy crops with those from food crops. The main problems in this case are the lack of information (for the farmer), the high inertia characteristic of the agricultural activity, the risks related to changing crop types and the absence of guarantees for the purchase of the crops for energy uses.
- *Actors directly affected by a negative externality from the project*. The renewable energy project may have a negative impact on certain actors. For example, noise from wind turbines may affect the cattle, visual intrusion may be regarded as negative by neighbours, etc. … However, these stakeholders would only organise to reject the project if such negative impacts were strong enough.
- *Other local actors are likely to benefit either directly or indirectly from the project*. Among the former, we can mention those employed in the project. Among the later, we can mention those favoured by an increase in local purchases of goods as a result of income from the project. Obviously, these stakeholders would be part of the support base for the project.
- Finally, there will probably be other actors who do not perceive to be affected by the project (neither positively nor negatively) and who therefore would not have an impact on its local acceptance or rejection. For example, some farmers are unlikely to be impacted directly by the project since the renewable energy installation is not located in their own land (in the case of wind or solar PV) or because they are not changing their crop type in order to produce biomass for energy uses. These actors are unlikely to have a strong opinion either in favour or against the project.

4.2.4. Local NGOs, local organisations and farmers cooperatives

Environmental NGOs may be a key player in negative terms because they might reject the project if it causes significant negative environmental externalities (such as noise, visual intrusion or impacts on local ecosystems or fauna). Although renewable energy projects are "cleaner" than conventional energy sources, their negative externalities may rise as a result of the increase in RES deployment and the concentration of projects in certain locations, leading to higher rejection by the local population.

On the other hand, local organisations and farmers associations may regard the project as a positive development alternative for the local community, encouraging income and employment diversification.

4.2.5. Actors outside the region/local community

These might be either positively or negatively affected by renewable energy deployment but, in either case, they are unlikely to make much fuss, i.e., they will probably not have a significant effect on either the acceptance or rejection of the deployment of renewable energy projects or renewable energy policy:[21]

- Electricity consumers paying for the renewable energy support policy.
- Consumers of food products experiencing an increase in product prices.
- Citizens in general benefiting from a cleaner environment.

[21]For example, the RES support policy is paid by the majority of ignorant and uninformed electricity consumers. In addition, since the total costs are not high compared to the large number of electricity consumers who would pay for them, these are not likely to organise and make noise anyway (i.e., even if they knew). The costs of information and organisation are too high for these actors.

5. Concluding remarks

This paper has developed an integrated and comprehensive theoretical framework for the analysis of the impact of RES on local (rural and regional) sustainability, focusing on the social and economic dimensions. This framework can be empirically applied to show these benefits in different developed countries. Previous papers have considered only some of the socioeconomic benefits of renewable energy deployment for local communities and, although some of them have even provided anecdotal evidence of their existence, an integrated conceptual framework to analyse them has been absent.

Furthermore, the existing literature has mainly focused on the direct employment effects associated to renewable energy deployment as the most important contribution to local sustainability. However, a wide array of other tangible and non-tangible benefits should be considered, including income generation which complements and diversifies the sources of income of the local population. The creation of a development alternative provides them with brighter prospects and, thus, has a positive psychological effect on isolated rural communities.

In fact, a key issue nowadays in many OECD countries is how to improve the standard of living of the rural population with a high dependence on a declining agricultural sector, high unemployment rate and scarcity of regional development alternatives. Regional development policies have long been justified and implemented in developed countries in order to reduce regional disparities and increase the quality of life of people in depressed regions. There is much to be gained from a regional development policy which takes advantage of the deployment of renewable energy projects. This paper has shown that such a policy could bring several local benefits.

However, this policy may also have considerable costs, some of which may fall on the local population (i.e., increasing negative environmental externalities) while others (the costs of promotion) are borne by consumers and taxpayers who live in the wider territory (country) surrounding the region or local community. Therefore, the local benefits should be put on a balance with the more widespread costs of such a policy. In efficiency terms, such costs are worth incurring only if they would lead to net social benefits. In equity terms, the benefits may fall inequitably on different actors. The main beneficiaries of such a policy are likely to be renewable energy generators and investors and the population of rural areas, whereas electricity consumers pay the costs of policy support. However, given the predominantly low income of rural areas compared to urban areas in OECD countries, this income transfer probably makes renewable energy support policy a socially cohesive policy which may help mitigate the income differences between and within territories and, thus, it can be defended on equity grounds. It can also reduce rural migration, which certainly has socioeconomic and environmental benefits on its own. We do not claim, however, that a social cohesion policy should be exclusively based on a renewable energy policy. In fact, a coordinated and integrated interregional (national) policy is more suitable for this task. We only argue that renewable energy policy can make a (modest) contribution in that direction, because regional cohesion policy and renewable energy policy have obvious positive synergies which should be exploited.

Further research should focus on the empirical front, showing the viability of the proposed approach. Qualitative and quantitative studies should be carried out to show the different socioeconomic benefits of renewable energy in specific places and locations. This

will inform policy makers on the local benefits of renewable energy deployment and, hopefully, help mitigate some of the problems being faced by RES investors (including delays caused by administrative procedures and authorisations).

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